

ANNEX IV

Growth and Yield Program



2017-2027 DFMP

Prepared by FORCORP
July 7, 2017





Binder	Type	ID	Name
ONE	Executive Summary		
	Chapter	1	Corporate Overview and Forest Management Approach
	Chapter	2	DFMP Development
	Chapter	3	Forest Landscape Assessment
	Chapter	4	Summary of Previous DFMP
	Chapter	5	Values, Objectives, Indicators, and Targets (VOITs)
	Chapter	6	Preferred Forest Management Scenario
	Chapter	7	DFMP Implementation
	Chapter	8	Research
	Glossary		
TWO	Annex	I	Forest Management Agreement (FMA)
	Annex	II	Communication and Consultation Plans
	Annex	III	Stewardship Report 2007-2011
	Annex	IV	Growth and Yield Program
	Annex	V	Growth and Yield
	Annex	VI	Timber Supply Analysis
	Annex	VII	Spatial Harvest Sequence
THREE	Annex	VIII	Landbase Development Document



Executive Summary

Millar Western is currently undertaking the development of a 2017-2027 DFMP that encompasses both FMUs. As part of the DFMP planning process, this Growth and Yield Program has been developed to outline growth and yield requirements and to describe the means by which these requirements will be met.



Table of Contents

1.	Introduction	1
1.1	Background	1
1.2	Growth and Yield Program Information	2
1.2.1	Permanent Sample Plot (PSP) Program	2
1.2.2	Standard Permanent Sample Plots (SPSPs).....	2
1.2.3	Plantation Permanent Sample Plots (PPSPs)	2
1.2.4	Non-Productive Permanent Sample Plots (NPSPs)	3
1.2.5	Regenerated Permanent Sample Plots	3
1.3	Temporary Sample Plot (TSP) Programs	3
1.4	Growth and Yield Association Involvement.....	5
1.4.1	Forest Growth Organization of Western Canada.....	5
1.4.2	Policy and Practice Project Team	5
1.4.3	Foothills Pine Project Team	5
1.4.4	Mixedwood Project Team	5
1.4.5	Tree Improvement Alberta	6
2.	Growth Model Development	7
3.	Yield Estimation	9
3.1	Natural Stands.....	9
3.1.1	Available Data	9
3.2	Managed Stands.....	10
3.2.1	Available Data	10
4.	Growth and Yield Monitoring	13
4.1.1	Natural Stands.....	13
4.1.2	Managed Stands.....	14
4.1.3	Managed Stand PSP Requirements for G&Y Monitoring.....	15
5.	Other Initiatives	19
5.1	Realized Gain Trials	19
6.	Future Sampling	21
6.1	New PSP and Pseudo-PSP measurements	21
6.2	New TSP measurements	21
7.	Implementation Schedule.....	23
8.	Reporting on Previous Plan.....	27
8.1	Forest Inventory.....	27
8.2	Temporary Sample Plots (TSP's)	27
8.3	Regeneration Surveys	28



8.4	Permanent Sample Plot Program.....	28
8.5	Regenerated PSP Initiative.....	29
8.6	In-Block Roads.....	30
8.7	Tree Improvement	30
8.8	Mortality and Ingress	31



List of Tables

Table 1. TSP program summary	4
Table 2. Summary of Millar Western PGYI Plot Commitments by Plot Type and Stratum.....	7
Table 3. Summary of natural stand TSP’s to be available for yield forecasting for 2027-2036 DFMP	10
Table 4. Summary of managed-stand TSP’s available for yield forecasting for 2027-2036 DFMP.....	11
Table 5. Summary of managed-stand PSP’s available by curve type for yield forecasting for 2027-2036 DFMP	11
Table 6. Summary of managed-stand PSP’s available by curve type for yield forecasting for 2027-2036 DFMP	12
Table 7. Summary of existing PSP’s in natural stands.....	14
Table 8. Summary of existing PSP’s in W11 in managed stands following aggregation.....	15
Table 9. Summary of existing PSP’s in W13 in managed stands following aggregation.....	15
Table 10. PSP targets and additional plot requirements for W11	16
Table 11. PSP targets and additional plot requirements for W13	17
Table 12. Measurement schedule for existing “PGYI” and “Non-PGYI” PSP’s by plot type.	24
Table 13. Establishment (and subsequent re-measurement) schedule for PSP’s and Pseudo-PSP’s for Millar Western	24
Table 14. Establishment (and subsequent re-measurement) schedule for PSP’s for Spruceland Millworks Ltd.....	25
Table 15. Establishment schedule for TSP’s.....	25
Table 16. Number of plots completed by FMU, stratum and type.....	28
Table 17. Status of grid-based PSP’s	29
Table 18. Grid-based PSP’s established 2007-2016 by plot type.....	29
Table 19. Grid-based PSP’s re-measured 2007-2016 by plot type	29
Table 20. Regenerated PSP’s established 2007-2016.....	30
Table 21. Regenerated PSP’s re-measured 2007-2016.....	30



1. Introduction

1.1 Background

This document describes Millar Western's Growth and Yield Program. The program is structured around requirements identified in the draft GOA document: Growth and Yield Programs, October 26, 2016 and ongoing discussions with GOA. The document includes a summary of the sampling programs carried out to date and proposes new sampling to take place in support of the 2027-2036 DFMP. Upon approval by GOA, this program will replace Millar Western's existing program.

The cornerstone of Millar Western's Growth and Yield Program is the Permanent Sample Plot (PSP) Program which was implemented in 1995, to provide unbiased growth and yield data, which would ultimately be used in yield estimation. However, in recent years, yield estimation has shifted away from traditional modeling approaches to the use of provincially approved growth models. For natural stands, robust data sets were used to develop these models and they generally perform very well. There is more uncertainty surrounding projecting managed stand yields using the growth models. As such, Millar Western is in the process of re-examining its PSP programs so that more data is available from managed stands to support model development and yield monitoring. This increased focus on managed stand PSP's will likely mean that many of the natural stand PSP's will be retired, or harvested and subsequently converted to managed stand PSPs. The amount of natural stands PSP listed in this document is likely to diminish as the PSP Program is re-vamped. All Provincial Growth and Yield Initiative (PGYI) plots will be maintained.

This growth and yield program document describes the data that will be collected in support of the three key requirements identified by the Government of Alberta:

- Yield Estimation
- Growth Model Development
- Growth and Yield Monitoring

It also includes a detailed implementation schedule and a report on that status of commitments made in the previous plan.



1.2 Growth and Yield Program Information

1.2.1 Permanent Sample Plot (PSP) Program

In 1995, Millar Western initiated a permanent sample plot (PSP) program to provide long-term, forest-wide, unbiased estimates of forest vegetation change, both in terms of timber and non-timber values (Millar Western 2004).

Permanent sample plot establishment began in 1995. In 1995 and 1996, PSPs were established using a combination of systematic and stratified random sampling. After 1996, a 3000 m x 3000 m grid (oriented N-S and E-W) was established across the Millar Western FMA area, and all subsequent PSPs have been established on this grid. In this document, the plots are classified as grid-based PSP's

There are three types of permanent sample plots within the PSP program: Standard Permanent Sample Plots (SPSPs), Plantation Permanent Sample Plots (PPSPs) and Non-Productive Permanent Sample Plots (NPSPs).

PSP data collection protocols vary slightly depending on the type of stand the grid point falls in. Data collection protocols are described below. All measurement protocols meet the minimum standards developed through the Provincial Growth and Yield Initiative (PGYI).

1.2.2 Standard Permanent Sample Plots (SPSPs)

Standard PSPs are established when a grid point falls on a natural stand within the managed landbase.

An 11.28 m radius (0.04 ha) main plot is established with a 20 m buffer. Within this plot, all trees ≥ 1.3 m in height are tagged, stem mapped and measured (species, DBH, height, height to live crown, crown class, crown development and applicable quality codes). Breast height age is collected from two top height trees of each species group found in the plot (provided that species comprises at least 10% of the plot). A 40m² regeneration plot is used to assess trees greater than 30cm in height, but less than 1.3 metres. Lower vegetation is assessed using a 10m² plot located at plot centre and assess percentage cover of shrubs, herbs/forbs, grass and moss/lichen.

SPSP's in stands less than 40 years of age are re-measured on a 5-year cycle, while stands 40 years or age or greater are measured on a 10-year cycle.

1.2.3 Plantation Permanent Sample Plots (PPSPs)

Plantation PSPs are established when a grid point falls on a managed stand within the managed landbase, or when a Standard PSP is harvested and the PSP is subsequently re-established. In other words, PPSPs sample regenerating (post-harvest) stands. Reestablishment will occur immediately after planting in order to track seedling growth and survival; in leave for natural (LFN) stands, reestablishment will occur as soon as possible after harvesting in order to capture vegetation and site dynamics.

All protocols outlined for SPSPs will be followed for PPSPs, with the following exceptions:

1. In addition to tagging all seedlings ≥ 1.3 m in height, all planted seedlings under 1.3 m in height will be tagged. Unlike other tagged seedlings, these seedlings will not be assessed for height to live crown, DBH or crown class.
2. Regeneration type (natural, planted, advance, unknown) will be assigned to all tagged stems.



PPSP's will be re-measured on a 5-year cycle until the cutblock reaches 40 years of age, at which point it will shift to a 10-year measurement cycle.

1.2.4 Non-Productive Permanent Sample Plots (NPSPs)

Non-Productive PSPs are established when a grid point falls on a natural stand within the unmanaged landbase. All protocols outlined for SPSPs will be followed, although for certain NPSP types (*e.g.*, shrubs or grasses), the plot will be devoid of trees.

All NPSP's will be re-measured on a 10-year cycle.

1.2.5 Regenerated Permanent Sample Plots

In 2008, Millar Western initiated a program to expand the number of PSP's located in managed stands. A stratified random approach, focused on conifer-leading blocks, was used to select blocks for sampling. Pre-1991 blocks were classified using AVI, while younger blocks were classified using silviculture records. Once blocks were selected, random grid locations were used to locate plot centers. These plots are considered to be PPSP's since they are collected using the same protocols and have the same re-measurement frequency.

1.3 Temporary Sample Plot (TSP) Programs

Millar Western has undertaken various TSP data collection programs to support yield curve development. Sampling programs were conducted in 1997, 1998, 2004 and 2014. Data collection in 1997 and 1998 was restricted to FMU W13 (prior to incorporation of FMU W11); data collection in 2004 and 2014 was undertaken in both FMUs. Various data collection protocols have been used. Information for all programs is summarized in Table 1.



Table 1. TSP program summary

	Program Type				
	TSP 1997	TSP 1998	TSP 2004	Juvenile TSP	TSP 2014
Sampling Frame	Operable landbase; minimum stand height = 8 m	Operable landbase; minimum stand height = 8 m	Operable landbase; minimum age=40 years (no minimum height)	Juvenile post-harvested stands age 20 – 50 years	Operable landbase; minimum stand height = 8 m
Sampling Location	W9 (subset of W13)	W5 (subset of W13)	W13 and W11	W13 (PA, PL, SA and SW strata)	W13 and W11
Stand Selection	Random, area-weighted, by height class and yield stratum	Random, area-weighted, by height class and yield stratum	Random, area-weighted, by age class and yield stratum	Random, area-weighted, by yield stratum	Random, area-weighted, by yield stratum
Plot Selection	Random within stand; 15 m buffer along edge of stand to prevent straddle plots	Random within stand; 15 m buffer along edge of stand to prevent straddle plots	Random within stand; buffer width set to plot radius to ensure entire plot within stand	Random within stand; buffer width set to plot radius to ensure entire plot within stand	Random within stand; buffer width set to plot radius to ensure entire plot within stand
Number of Plots	3/stand	3/stand	3/stand	3/stand	3/stand
Plot Design	Tree and snag plot: 5.64/7.98/11.28 m radius depending on AVI crown closure and stand height Sapling plot = 2.82 m radius Shrub and ground vegetation plot = 1.78 m radius Coarse woody debris = 2 x 10 m transects	Tree and snag plot: 5.64/7.98/11.28 m radius depending on AVI crown closure and stand height Sapling plot = 2.82 m radius Shrub and ground vegetation plot = 1.78 m radius Coarse woody debris = 2 x 10 m transects	Tree and snag plot: 5.64/7.98/11.28 m radius depending on AVI crown closure and stand height Sapling plot = 3.99 m radius (BAP plots only) Shrub and ground vegetation plot = 1.78 m radius (BAP plots only) Coarse woody debris = 3 x 30 m transects (BAP plots only) Snag cruise = 100 m transect (BAP plots only)	Tree plot: 5.64 m radius Sapling plot = 3.99 m radius Regen plot = 1.78 m radius Top height tree plot = 7.98 m radius	Tree plot: 5.64/7.98/11.28 m radius depending on AVI crown closure Sapling plot = 2.82 m radius Regen plot = 1.78 m radius Top height tree plot = 7.98 m radius
Data Collection: All Plots	Trees - species, DBH, height, height to live crown, height to dead crown, crown class, number of dead limbs, presence of bark crevice cavities, lichen cover class, quality codes, subsample of breast height ages	Trees - species, DBH, height, height to live crown, height to dead crown, crown class, number of dead limbs, presence of bark crevice cavities, lichen cover class, quality codes, subsample of breast height ages	Trees - species, DBH, height, height to live crown, crown class, lichen cover class, quality codes, number of coppice suckers, crown development code	Trees - species, DBH, height, lean, quality codes, total ages of top height trees	Trees - species, DBH, height, lean, quality codes, breast height ages of top height trees
Data Collection: Additional BAP	Snags - species, DBH, height, decay class, bark class Saplings - same as for trees Shrubs - species/species class, percent cover class, average height Ground vegetation - species group, percent cover class Coarse woody debris - species group, diameter at intersection, decay class, inclination, stump top diameter, stump height, height above ground	Snags - species, DBH, height, decay class, bark class Saplings - same as for trees Shrubs - species/species class, percent cover class, average height Ground vegetation - species group, percent cover class Coarse woody debris - species group, diameter at intersection, decay class, inclination, stump top diameter, stump height, height above ground	Snags - species, DBH, height, decay class, bark class Saplings - same as for trees (BAP plots only) Shrubs - species/species class, percent cover class, average height, total shrub percent cover, total shrub average height (BAP plots only) Ground vegetation - species group, percent cover class, total percent herb cover, total percent moss cover (BAP plots only) Coarse woody debris - species group, diameter at intersection, decay class, inclination (BAP plots only) Snag cruise - species group, DBH, estimated height, decay class, bark class, lichen cover class (BAP plots only)	Saplings - same as for trees except age Regen - species, count	Saplings - same as for trees except age Regen - species, count
Year(s) Collection	1997	1998	2004, 2005	2013, 2014, 2015	2014, 2015
Important Notes		1) BAP data not collected on all plots	1) BAP data not collected on all plots; 2) Minor additional birch stand sampling occurred in 2005 under the 2004 TSP protocols	Tree plot: 5/stand, 3.99 m radius; Top height tree plot: 5.64 m radius; in the 2013 Pilot Program.	Sampling plot: 3.99 m radius in the 2014 field season.
Yield stratum was used as the bases for the stratification category, however a number of stratification rules were applied					



1.4 Growth and Yield Association Involvement

1.4.1 Forest Growth Organization of Western Canada

Millar Western has been a member of the Forest Growth Organization of Western Canada (FGrOW) since its inception in 2015. FGrOW is an amalgamation of four Alberta-based growth and yield associations: Alberta Forest Growth Organization (AFGO), Foothills Growth and Yield Association (FGYA), Mixedwood Management Association (MWMA) and Western Boreal Growth and Yield Association (WESBOGY). Prior to amalgamation, Millar Western was a member of AFGO, FGYA and MWMA. Following amalgamation these association became the Policy and Practice, Foothills Pine and Mixedwood Project Teams under FGrOW.

1.4.2 Policy and Practice Project Team

The Policy and Practice Project Team started out as the Alberta Forest Growth Organization (AFGO). The original mandate of AFGO was to expedite and co-ordinate the development of a recognized, secure and well-funded forest growth and yield sector in Alberta, however this mandate was adopted by FGrOW following amalgamation. The Policy and Practice Project Team now focuses on projects that can improve growth and yield policy and practice in Alberta. A key project of the Policy and Practice Project Team is the Provincial Growth and Yield Initiative (PGYI), which is a cooperative data collection and management program, whereby each member contributes data into a central database. The data is then made available to members and various modellers and researchers interested in the data.

1.4.3 Foothills Pine Project Team

The Foothills Pine Project Team started out as the Foothills Growth and Yield Association (FGYA) and carries the mandate to forecast and monitor the growth and yield of managed lodgepole pine stands. A key project of the Foothills Pine Project Team is the Regenerated Lodgepole Pine (RLP) Trial. This is a long-term study that was initiated in 2000 to answer questions relating to early stand conditions, subsequent growth and yield, responses to initial spacing and pre-commercial thinning, and effects of site on lodgepole pine stands. Data from this study was used to create the Foothills Reforestation Interactive Planning System (FRIPSY). FRIPSY is a predictive decision support tool used in conjunction with other data and models for reforestation and yield planning of stands regenerated following harvest. Other active projects of the Foothills Pine Project Team include, the Historic Research Trial Re-measurements and Stand Dynamics after Mountain Pine Beetle Attack.

1.4.4 Mixedwood Project Team

The Mixedwood Project Team (formerly the Mixedwood Management Association of Alberta) works collectively with members in the application of mixedwood management in Canada's western boreal forest, and to advance the science and implementation of mixedwood forestry in the western boreal forests of Canada. The Mixedwood Project Team maintains two long-term trials: The Dynamic Aspen Density Experiment (DADE), studying the effects of different aspen overstories on spruce growth; and the Strip-Cut Understory Protection (SCUP) Trial, examining the response of understory spruce trees and regenerating aspen following strip harvesting treatment with understory protection. The Mixedwood project team is also working on a new version of the Mixedwood Silviculture Guide.



1.4.5 Tree Improvement Alberta

Millar Western is a founding member of Tree Improvement Alberta, which also started out as a stand-alone organization, but was amalgamated under the FGrOW umbrella in 2016. Tree Improvement Alberta was established to facilitate the delivery of programs or projects related to forest genetics in Alberta. The initial project under TIA authority was the three year Tree Species Adaptation Risk Management project funded by Climate Change and Emissions Management Corporation (CCEMC). Tree Improvement Alberta is currently involved in a project with member companies and FRIAA to establish realized gain trials. Realized gain trials are required in order to assess the performance of genetic stock under normal, operational reforestation conditions. Realized gain trials are necessary in order to properly quantify growth and yield gains associated with tree improvement programs.



2. Growth Model Development

Millar Western intends to use growth models for developing yield estimates for the foreseeable future. As such, Millar Western has a vested interest in ensuring suitable data is available for continued model development. Millar Western is a member of the Provincial Growth and Yield Initiative (PGYI) and will establish and re-measure its assigned PSP's according to PGYI standards and timelines. This data will be made available to modelers so that models can continue to be refined and improved over time. Millar Western may also provide other data, not contributed through PGYI, upon request. Table 2 summarizes the plots Millar Western has committed to PGYI by plot type and stratum.

Table 2. Summary of Millar Western PGYI Plot Commitments by Plot Type and Stratum

Stratum	Plot Type		Total
	Managed	Natural	
AW	5	6	11
AP	0	1	1
AS	2	1	3
PA	3	2	5
SA	1	1	2
PL	12	6	18
SW	15	4	19
SB	0	4	4
Total	38	25	63

All plots committed to PGYI by Millar Western have already been established. Plots will be re-measured at 5 year intervals until the stand reaches 40 years of age, after which re-measurements will shift to a 10-year cycle.



3. Yield Estimation

This section describes Millar Western's plan for creating yield curves for the next DFMP. Millar Western plans to use provincially approved growth models to estimate yield for the 2027-2036 DFMP. Growth models will be initiated using a combination of TSP's, PSP's and RSA data.

Millar Western does not plan on completing a new vegetation inventory for the 2027-2036 DFMP, but rather, will do an AVI update and potentially enhance the inventory in critical areas (*i.e.* Windfall Burn, older cutblocks approaching merchantability). Further discussions regarding inventory updates are expected to take place with GoA prior to development of the next DFMP.

3.1 Natural Stands

3.1.1 Available Data

The majority of the data used for estimating natural stand yields for the 2027-2026 FMP will come from TSP's. A small amount of PSP data will be available as well, but there is a strong likelihood that many of the natural-stand PSP's that are not committed to PGYI, will either be retired or harvested and converted into managed stand plots. To address any data shortfalls and provide data to represent current conditions in natural stands, new TSP's will be established. New TSP's will be established according to the following criteria:

- new TSP's will comprise a minimum of one third of the stratum target for natural stands
- a minimum of two thirds of the stratum target for natural stands will be comprised of TSP's that were established in 2004 or later
- new TSP's will be completed within four years of planned submission date of the next DFMP
- Stratum targets were set based on relative abundance by FMU

Table 3 summarizes the numbers of TSP's currently available by sampling period, identifies expected plots lost to harvesting (using spatial harvest sequence) and identifies the amount of new TSP's to be established. Data is summarized by FMU and stratum.



Table 3. Summary of natural stand TSP's to be available for yield forecasting for 2027-2036 DFMP

FMU	Stratum	Stratum Area (ha)	TSP Target	Existing TSP's			Remaining TSP's after removing plots in 1-10 year SHS			New TSP's to be Established	Total TSP's Available for 2027 DFMP
				Pre-2004	2004+	Total	Pre-2004	2004+	Total		
W11	AW	40,949	90	91	77	168	80	57	137	30	167
	AP	2,653	30	14	27	41	13	17	30	10	40
	AS	7,043	30	14	38	52	13	29	42	10	52
	PA	2,163	30	7	12	19	7	5	12	18	30
	SA	5,466	30	21	18	39	19	17	36	10	46
	PL	9,332	60	42	81	123	33	42	75	20	95
	SW	5,541	60	21	54	75	18	31	49	20	69
Total		73,147	330	210	307	517	183	198	381	118	490
FMU	Stratum	Stratum Area (ha)	TSP Target	Existing TSP's			Remaining TSP's after removing plots in 1-10 year SHS			New TSP's to be Established	Total TSP's Available for 2027 DFMP
				Pre-2004	2004+	Total	Pre-2004	2004+	Total		
W13	AW	32,164	90	40	54	94	36	44	80	30	110
	DU	10,570	60	15	32	47	12	26	38	22	60
	AP	5,060	30	11	23	34	10	9	19	11	30
	AS	11,739	60	24	29	53	22	24	46	20	66
	PA	4,351	30	19	21	40	13	11	24	10	34
	SA	7,773	60	20	24	44	16	15	31	29	60
	PL	35,323	90	97	42	139	70	23	93	37	130
	SW	12,059	90	31	42	73	26	24	50	40	90
	SB	7,353	30	3	31	34	3	25	28	10	38
Total		126,391	330	260	298	558	208	201	409	209	618

3.2 Managed Stands

3.2.1 Available Data

Data for estimating managed-stand yields for the 2027-2016 DFMP is expected to come from RSA sampling, PSP's and TSP's. Managed-stand TSP data, collected in support of the 2017-2026 DFMP, as well as numerous managed-stand PSP's, will be used for model initiation in the 2027-2036 DFMP. In addition, a new TSP program is planned for managed stands in W13.

This program will target data gaps across different eras of regeneration so that a representative managed-stand yield curve can be developed for the next DFMP. The similarity of the RSA managed-stand yield curves and the pre-1991 managed-stand yield indicate that a single yield curve for regenerating stands is appropriate, but having representation across all regeneration eras is essential. The exception to the similarities between the pre-1991 and the RSA curves is the PL stratum, which does show a significantly high MAI in the RSA curve, relative to the pre-1991 curve. There should be adequate TSP and PSP data available in the PL stratum to build separate curves for the pre-1991 and RSA



population of cutblocks. Table 4 summarizes the existing and proposed TSP's in W13 by stratum that will be available for the 2027-2036 DFMP. New managed stand TSP's will be completed between 2023 and 2025, so that they are available for yield curve development for the next plan. No managed-stand TSP's are planned for W11.

Table 4. Summary of managed-stand TSP's available for yield forecasting for 2027-2036 DFMP

FMU	Stratum	Existing TSP's				Proposed New TSP's				Total TSP's Available for 2027 DFMP			
		Pre-1980	1980-1990	1991-2005	Total	Pre-1980	1980-1990	1991-2005	Total	Pre-1980	1980-1990	1991-2005	Total
W13	AW	0	0	0	0	0	15	15	30	0	15	15	30
	PA	16	48	0	64	0	0	20	20	16	48	20	84
	SA	11	26	0	37	4	0	16	20	15	26	16	57
	PL	3	43	0	46	15	0	15	30	18	43	15	76
	SW	11	25	0	36	9	0	21	30	20	25	21	66
Total		41	142	0	183	28	15	87	130	69	157	87	313

Table 5 and Table 6 show the number of PSP's in managed stands in W11 and W13 respectively that will be available for yield forecasting in the 2027-2036 DFMP.

Table 5. Summary of managed-stand PSP's available by curve type for yield forecasting for 2027-2036 DFMP

FMU	Stratum	Stratum Area (ha)*	Type of Regenerated Yield Curve		Total
			Basic	RSA	
W11	AW	8,233	7		7
	AP	0	1		1
	AS	0	1		1
	PA	0			0
	SA	0	1		1
	PL	1,698	1	2	3
	SW	4,390		1	1
	SB	0	1		1
Total			12	3	15



Table 6. Summary of managed-stand PSP's available by curve type for yield forecasting for 2027-2036 DFMP

FMU	Stratum	Stratum Area (ha)*	Type of Regenerated Yield Curve				Total
			Basic	Juvenile (Pre-1991)	RSA (1991+)	RSA_TI	
W13	AW	11,002	16				16
	AP	1,401					0
	AS	1,138	4		2		6
	PA	3,933		6	3		9
	SA	2,766		2	2		4
	PL	31,037		16	46		62
	SW	12,833		7	46	2	55
	SB	0	1				1
Total			21	31	99	2	153

* Does not include regenerated areas being modeled on a natural (basic) curve, except for AW because it is being modeled on a scaled natural curve



4. Growth and Yield Monitoring

This section outlines Millar Western's plan for monitoring natural and managed stand yields. The purpose of monitoring is to compare the observed growth of a yield stratum compared to its projected yield from the yield curve.

4.1.1 Natural Stands

A combination of PSP's and new TSP's will be used to monitor growth and yield in natural stands. A TSP program will be completed in advance of the 2027-2036 DFMP to ensure current and representative data is available for creating yield curves. Yield estimates generated from this data will be compared to yield estimates from the current plan to identify and account for any significant changes.

A number of natural stand PSP's are currently available to use for growth and yield monitoring, although as mentioned previously, not all of these PSP's will be maintained over time. Table 7 summarizes the natural stand PSP's currently on the landbase by stratum.



Table 7. Summary of existing PSP's in natural stands

Stratum	FMU		Total
	W11	W13	
AW	42	25	67
DU	0	5	5
AP	2	8	10
AS	5	12	17
PA	0	15	15
SA	4	4	8
PL	9	82	91
SW	4	20	24
SB	10	29	39
Total	76	200	276

4.1.2 Managed Stands

For the purpose of monitoring managed-stand growth and yield, Millar Western intends to aggregate all PSP's within a managed stand stratum regardless of yield curve type (Basic, Juvenile, RSA, RSA_TI). This will provide a meaningful amount of PSP data for assessing stratum-level performance for a reasonable amount of investment dollars.

With the exception of the PL stratum, RSA and Juvenile (Pre-1991) curves are showing very similar growth projections, indicating that there is little point in segregating the different regeneration eras going forward. The significant differences in silviculture practices between eras have caused shifts in strata (ie. SW plantations moving into SA and AS strata types), but once a stratum has stabilized, it seems to perform in line with RSA projections for that same stratum.

TSP's established in older managed stands (greater than 40 years old) will also be used for monitoring purposes and will be beneficial in assessing overall performance of the growth model in stands approaching merchantability.

Table 8 and Table 9 show the number of managed stand PSP's in each stratum following aggregation for W11 and W13 respectively.



Table 8. Summary of existing PSP’s in W11 in managed stands following aggregation

FMU	Stratum	All Regeneration Curves
W11	AW	7
	AP	1
	AS	1
	PA	0
	SA	1
	PL	3
	SW	1
	SB	1
Total		15

Table 9. Summary of existing PSP’s in W13 in managed stands following aggregation

FMU	Stratum	All Regeneration Curves
W13	AW	16
	AP	0
	AS	6
	PA	9
	SA	4
	PL	62
	SW	55
	SB	1
Total		153

4.1.3 Managed Stand PSP Requirements for G&Y Monitoring

For growth and yield monitoring purposes, Millar Western plans to establish and maintain a target number of managed-stand PSP’s in each regenerated yield stratum. The target number of plots in each stratum is dependent on the significance of the stratum on the landbase. Large strata will have a target of 30 plots, whereas minor strata will have a target of 20 plots. Due to the similarity in management practices and ecosites, combined with the high cost of establishing maintaining plots, Millar Western intends to pool the AW PSP’s from W11 and W13 for monitoring purposes. As such, the target number of managed-stand PSP’s in AW landbase has been set at 15 plots each for W11 and W13, for a total of 30 plots.

In W11, Spruceland Millworks Ltd. owns 100 percent of the conifer harvesting rights, and as such should bear the cost of establishing and maintaining any PSP’s that are required to support growth and yield monitoring associated with the use of RSA-based yield curves. Millar Western has had some preliminary discussions with Spruceland Millworks Ltd. and they have agreed in concept to this commitment. Millar Western will work with Spruceland Millworks Ltd. to come up with a cost effective PSP program that will allow them to establish and re-measure the required plots in a cost effective manner. Table 10 shows the managed-stand PSP targets and additional plot requirements for regenerated strata in W11.



Table 10. PSP targets and additional plot requirements for W11

FMU	Stratum	PSP Target	Available PSP's	Additional PSP's Required
W11	AW	15	7	8
	PL	20	3	17*
	SW	20	1	19*
Total		45	11	44

* Spruceland Millworks Ltd. commitment

In W13, the mixedwood strata were rolled up by leading conifer species due relatively small size of individual strata on landbase and the tendency of strata to migrate from one stratum to the other. PA/AP and SA/AS requirements have been set at 30 plots for W13, but plot requirements will be satisfied using a combination of PSP's and Pseudo-PSP's. Pseudo-PSP's will help to keep growth and yield program costs down in the short-term, and allow Millar Western to disperse the establishment of permanent PSP's across a long time frame, so that the sampling will capture differences in silviculture regimes over time. This is especially important in the mixedwood stand types, since it has been a relatively short time since Millar Western has been planning and establishing intimate mixedwoods. The majority of the managed-stand mixedwoods on the landbase today originated from failed attempts to produce conifer cutblocks.

The sampling standards for the pseudo-PSP's has not yet been finalized, but the basic measurement parameters will be as follows:

- 200m² fixed area tree plot, with nested 50m² sapling plot and 10m² regeneration plot
- Randomly located within target strata
- Maximum 1 plot per polygon
- Permanently referenced using GPS
- All trees will be marked for relocation
- Trees outside the plot will be marked as out
- Species, height, DBH, lean, and quality will be assessed for all trees and saplings
- Regeneration will be tallied by species in regeneration plot
- Moisture, slope and aspect will also be assessed

Table 11 shows the managed-stand PSP targets and additional plot requirements (PSP and Pseudo-PSP) for regenerated strata in W13.



Table 11. PSP targets and additional plot requirements for W13

FMU	Stratum	PSP Target	Available PSP's	Year 1-10 PSP's Required	Pseudo-PSP's Required
W13	AW	15	16	0	0
	PA/AP	30	9	11	10
	SA/AS	30	10	10	10
	PL	30	62	0	0
	SW	30	55	0	0
Total		85	152	21	20



5. Other Initiatives

5.1 Realized Gain Trials

In cooperation with Tree Improvement Alberta, Millar Western has committed to completing 10 realized gain trial installations for Region I white spruce. The trials will be used to assess the performance of genetically improved stock relative to stock produced from natural seed. The trial will consist of paired plots across a uniform site. The intention of the paired plots is to reduce the variability between the paired plots so that the growth of the genetically improved stock can be assessed relative to the unimproved stock. Establishment of the realized gain trials is expected to be completed within 3 years. Re-measurements are planned to occur on 5-year intervals.



6. Future Sampling

6.1 New PSP and Pseudo-PSP measurements

New PSP's will follow Millar Western's PSP collection protocols, which satisfies all of the requirements of the "Minimum Standards and Suggested Protocol and Priorities for Establishing and Measuring Permanent Sample Plots in Alberta" developed by PGYI in 2015. The pseudo-PSP collection protocols are not yet developed, but are briefly described in the Growth and Yield Monitoring section.

Plots locations will be selected using a stratified random sample to select stands. Selected stands will be gridded and grid locations will be assigned a random number. The lowest number will be the first potential plot location that will be visited by the field crew. If the grid location satisfies plot suitability and species composition requirements, the PSP will be established at that grid location, otherwise the grid location with the next lowest number assigned to it will be visited and assessed for suitability. The process will continue until a suitable location is found.

6.2 New TSP measurements

New TSP programs will be very similar to the 2014 approved TSP programs that were used to collect data for the 2017-2026 DFMP. The following sampling parameters will apply:

- 3 temporary sample plots will be established within each target polygon.
- Volume sampling plot will be comprised of three nested, fixed radius plots.
 - A tree plot will be used to collect tree data (live trees ≥ 1.3 m in height with a diameter at breast height (DBH) > 7.0 cm), primarily for volume sampling purposes. The plot will be circular, varying in size from 0.04 ha (11.28 m radius)



to 0.01 ha (5.64 m radius). A top height tree plot is superimposed on the main sampling plot, and is intended to sample top height trees.

- A 50m² (3.99 radius) sapling plot will be used to sample all saplings (live trees \geq 1.3 m in height and \leq 7.0 cm DBH). It is superimposed on the center of the tree plot.
 - A 10 m² (1.78 m radius) regen plot will be used to count all regeneration trees (\geq 0.3 m and $<$ 1.3 in height). It is also superimposed on the center of the tree plot.
- Each tree will be assessed for species, DBH, height, lean and quality
 - A minimum of 2 top height trees by species group will be selected (4 trees for a 400m² plot). Each tree will have species, height and breast height age taken.

Prior to sampling, a TSP methodology will be developed and submitted to GoA for approval.



7. Implementation Schedule

This section outlines the timelines on which Millar Western plans to establish and re-measure PSP's and TSP's. This section presents a schedule for measuring plots committed to in previous sections of this document. Scheduling has been completed in consideration of when the data is required, and with the general intention of creating an “even flow” of PSP measurements, so that plot measurements do not vary widely from year to year.

Table 12 presents the proposed re-measurement schedule for existing PSP that will be maintained. The table separates the plots by “PGYI” and “Non-PGYI”. Note that there are no re-measurements scheduled for “Non-PGYI” standard PSP's. Millar Western is still evaluating the number of standard PSP's that will be maintained outside of PGYI commitments and, as such, has not included them in this table.



Table 12. Measurement schedule for existing “PGYI” and “Non-PGYI” PSP’s by plot type.

Plot Type	Number of Plots	Measurement Year										Number of Measurements
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
PGYI												
Non-Productive	5	2	0	0	0	0	0	0	0	0	3	5
Plantation	16	4	3	0	9	0	4	3	0	9	0	32
Regenerated	22	0	4	11	7	0	0	4	11	7	0	44
Standard	20	5	1	2	3	0	5	0	0	0	4	20
Total	63	11	8	13	19	0	9	7	11	16	7	101
Non-PGYI												
Plantation	36	5	29	0	0	2	5	29	0	0	2	72
Regenerated	81	21	6	14	17	23	21	6	14	17	23	162
Total	117	26	35	14	17	25	26	35	14	17	25	234
Grand Total	180	37	43	27	36	25	35	42	25	33	32	335

Table 13 presents the proposed establishment schedule for PSP’s and pseudo-PSP’s that will be established by Millar Western. Re-measurements for the established plots are also included in the table.

Table 13. Establishment (and subsequent re-measurement) schedule for PSP’s and Pseudo-PSP’s for Millar Western

Plot Type	Measurement Type	Measurement Year										Total
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
PSP												
Regenerated	Establishment	0	0	10	0	9	0	0	0	0	0	19
	Re-Measure	0	0	0	0	0	0	0	10	0	9	19
Total		0	0	10	0	9	0	0	10	0	9	38
Pseudo-PSP												
Regenerated	Establishment	0	0	0	0	0	0	5	5	5	5	20
	Re-Measure	0	0	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	5	5	5	5	20
Grand Total		0	0	10	0	9	0	5	15	5	14	58

Table 14 presents the proposed establishment schedule for PSP’s that will be established by Spruceland Millworks Ltd. Re-measurements for the established plots are also included in the table.



Table 14. Establishment (and subsequent re-measurement) schedule for PSP's for Spruceland Millworks Ltd.

Plot Type	Measurement Type	Measurement Year										Total
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Regenerated	Establishment	0	4	4	4	4	4	4	4	4	4	36
	Re-Measure	0	0	0	0	0	0	4	4	4	4	16
Grand Total		0	4	4	4	4	4	8	8	8	8	52

Table 15 presents the proposed establishment schedule for TSP's. TSP's are scheduled to be completed within a 3-year window, finishing in 2025, so that data is collected in proximity to the AVI update and available for yield forecasting for the next DFMP.

Table 15. Establishment schedule for TSP's

Plot Type	Measurement Year										Total
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Natural	0	0	0	0	0	0	110	110	107	0	327
Managed	0	0	0	0	0	0	40	40	50	0	130
Grand Total	0	0	0	0	0	0	150	150	157	0	457



8. Reporting on Previous Plan

This section reports on the status of the main commitments made in the previous plan covering the 2007-2016 DFMP period.

8.1 Forest Inventory

Commitment: Complete an inventory as required to meet the Alberta Forest Management Planning Standard

Result: A new inventory was completed in advance of the 2017-2026 DFMP

8.2 Temporary Sample Plots (TSP's)

Commitment: Develop a volume sampling plan to assess whether TSPs are required for yield curve development prior to the 2017-2026 DFMP

Result: A mature stand TSP program was completed in W11 and W13 to fill in data gaps and produce a representative data set for use in Yield Curve Development. The mature stand TSP program was designed to collect suitable top height and age information for all species groups represented in the plots, so that accurate yield estimates could be generated from the GYPSY growth model. In W13, a juvenile stand TSP program was also completed in order to provide data required to develop yield curves for blocks harvested prior to 1991. This sampling was also designed to collect all required data to generate yield estimates using the GYPSY growth model. Table 16 summarizes the number of plots completed by FMU, stratum and TSP type.



Table 16. Number of plots completed by FMU, stratum and type

Stratum	Mature Stand TSP's		Juvenile TSP's	Total
	W11	W13	W13	
AW	26	45	6	77
DU	0	14	0	14
AP	18	18	3	39
AS	21	15	14	50
PA	9	12	72	93
SA	9	15	42	66
PL	26	29	49	104
SW	31	31	49	111
SB	1	31	0	32
Total	141	210	235	586

8.3 Regeneration Surveys

Commitment: Carry out ASRD Regeneration Surveys (Establishment and Performance) on each cutblock as required by ASRD, until Alternative Regeneration Standards are developed and approved.

Result: The intent of this commitment was to develop Alternative Regeneration Standards, which was still an option when the last Growth and Yield Plan was completed. Alternative Regeneration Standards were later replaced with Regeneration Standards of Alberta (RSA), which Millar Western has been adhering to since inception.

8.4 Permanent Sample Plot Program

Commitment: Establish remaining grid-based PSP's by the end of the 2007-2016 planning period; as Standard PSP's are harvested, replace with Plantation PSP's, with a minimum of 10 SPSP's harvested over the 2007-2016 planning period; establish 1 EFM PSP per 250ha thinned.

Result: In total, 306 of the 413 planned grid-based PSP's have been established to date. The original intent was to have all of the grid-based plots established across W11 and W13. The shift towards using growth models for yield forecasting, combined with the reduction in the amount of natural stands on the landbase, has decreased the need for large numbers of natural stand PSP's. Table 17 provides a breakdown of the number of grid-based plots that have been established by plot type compared to the total planned number. Table 18 and Table 19 summarize the grid-based PSP's that were established and re-measured by plot type.



Table 17. Status of grid-based PSP's

Plot Type	Active	Planned	Total
Non Productive	44	9	53
Plantation	52	14	66
Standard	210	84	294
Total	306	107	413

Table 18. Grid-based PSP's established 2007-2016 by plot type

Plot Type	Establishment Year										Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Non- Productive	6	0	0	0	0	0	0	0	0	0	6
Plantation	12	0	0	12	4	0	0	0	0	0	28
Standard	25	0	0	3	0	0	0	0	0	0	28
Total	43	0	0	15	4	0	0	0	0	0	62

Table 19. Grid-based PSP's re-measured 2007-2016 by plot type

Plot Type	Re-Measurement Year										Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Non- Productive	0	0	0	0	0	0	0	0	0	0	0
Plantation	0	9	0	8	4	9	8	0	9	0	47
Standard	0	34	25	35	4	16	1	0	0	7	122
Total		43	25	43	8	25	9	0	9	7	169

Between 2007 and 2016, only two PSP's were harvested and converted to plantation PSP's. Prior to being eligible for harvest, PSP's were required to have at least three measurements. Unfortunately fewer than anticipated plots met this requirement when the adjacent timber was planned for harvest.

No areas were thinned between 2007 and 2016. Therefore no additional EFM plots were established.

8.5 Regenerated PSP Initiative

Commitment: Establish 100 Plantation PSP's in regenerating stands on a stratified basis over the next five years

Result: In total, 103 regenerated PSP's were established between 2008 and 2012. Three of the original 100 PSP's were destroyed by wildfire in 2011 and were replaced by 3 new plots. 82 of the plots have already been re-measured, while the other 18 are scheduled for re-



measurement in 2017. Table 20 and Table 21 summarize the regenerated PSP’s that were established and re-measured between 2007 and 2016.

Table 20. Regenerated PSP’s established 2007-2016

Plot Type	Establishment Year										Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Regenerated	0	10	25	25	25	18	0	0	0	0	103
Total	0	10	25	25	25	18	0	0	0	0	103

Table 21. Regenerated PSP’s re-measured 2007-2016

Plot Type	Re-Measurement Year										Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Regenerated	0	0	0	0	0	0	10	25	24	23	82
Total	0	0	0	0	0	0	10	25	24	23	82

8.6 In-Block Roads

Commitment: Collect additional in-block road data during ASRD regeneration surveys until 2007; establish 15 in-block road PSP plot pairs over the next five years.

Result: This initiative stemmed from section 5.9.9 of The Forest Management Planning Manual (Alberta SRD 2006), which states that there will be a 5% area reduction in regenerating stands to account for in-block roads and landings. To eliminate the need to net down the area of regenerating stands, Millar Western implemented an in-block road PSP program to validate that in-block roads are being regenerated and that there is sufficient height growth. Millar Western developed a protocol to collect this data and completed sampling in 6 blocks in 2007. The program, however, was short-lived, as the Government of Alberta eliminated the requirement to prove regeneration success on in-block roads. These plots have since been abandoned.

8.7 Tree Improvement

Commitment: Continue participation in progeny trial data collection and analysis; develop a protocol for PSP data collection.

Result: Millar Western maintains 2 progeny trial locations in support of Region I. Both of these progeny trials were established in 2001 and were subsequently re-measured in 2013. Millar Western, in cooperation with Tree Improvement Alberta members, helped to develop a protocol for establishing realized gain trials to prove out genetic gain in the field. Millar Western will be implementing 10 installations over the next 3 years.



8.8 Mortality and Ingress

Commitment: Establish 24 Mortality and Ingress PSP's every year until 2012

Result: Between 2007 and 2012, a total of 168 Mortality and Ingress Plots were established throughout W13. Many of these have been re-measured one or more times. In 2010, data was analyzed by Forcorp and summarized in a report. No new measurements are forecast on this project.



FORCORP - Project Number: P755
For additional information, please contact:
FORCORP Solutions Inc.
200-15015 123 Avenue NW
Edmonton, AB
T5V 1J7
(780) 452-5878
www.forcorp.com